Closed-Loop Neural Control of Rotor Noise and Vibration

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A study to identify and control helicopter rotor blade–vortex interaction (BVI) noise and vibratory hub loads using neural networks has been initiated at Ames Research Center. BVI noise can make a major contribution to the total rotorcraft noise, and can be annoying. The vibratory hub loads substantially determine the total rotorcraft vibration level. This vibration affects pilot and passenger comfort and the vehicle's structural fatigue life.

Current neural control simulation covers simultaneous control of BVI noise and vibratory hub loads by using an objective function approach. In the present study, the advancing side BVI noise and the vibratory hub load components were represented by two metrics, namely, the noise metric and the hub loads metric. The objective function was composed of the sum of the weighted squares of the noise and hub loads metrics. The closed-loop controller must be fast-executing and must converge quickly (in six iterations or less); gradient-based methods must not be used.

The identification (plant modeling) procedure was completed; it involved the use of a two-hidden-layer radial-basis function neural network with one input and two outputs. A simple, easy-to-implement neural control technique, the "direct inverse" method, was successfully applied and found to be robust. The present approach had the following essential ingredients: accurate plant modeling, halving of the metric in order to accelerate controller convergence, "inverted-axes" control modeling, and a feedback iterative loop. A simple, two-hidden-layer back-propagation neural network used in the control step was successful.

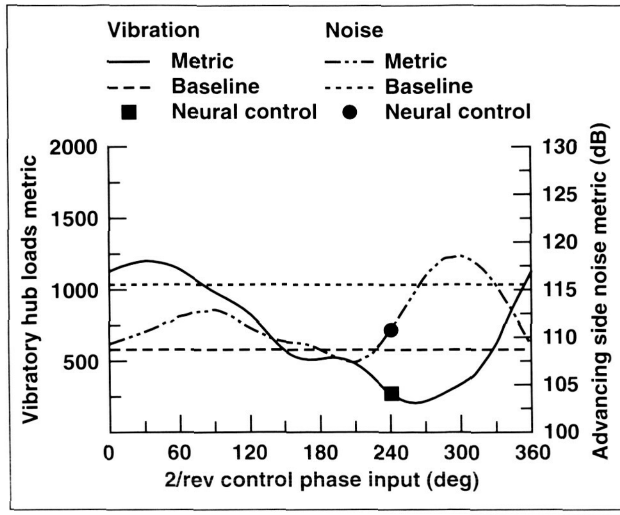

Fig. 1. Simultaneous noise and hub load reductions using present closed-loop neural network controller.

Results from the present, closed-loop neural network controller showed that simultaneous reductions of 5 decibels in the baseline noise and 54% in the baseline vibratory hub loads were achievable in only two controller iterations (these results are shown in the figure).

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